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Time Estimation And Hand Preference

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ABSTRACT

This work examines the effect of participants' gender and handedness on the perception of short intervals of time. The time estimation task consisted of an empty production procedure with forty trials at each of four intervals of one, three, seven, and twenty seconds. The four target intervals represent a natural logarithmic progression and a series that bracket important temporal thresholds. The order of presentation of those intervals was randomized across participants but yoked across the sexes in each of the respective dominant hand groups. The two between-subject factors, with two levels each, were sex and handedness. Participants produced forty estimates at each of the required intervals, which was the first within-subject factor, estimated interval being the other. T-tests were conducted on the dependent measures, the time estimates in terms of their variability and their central tendency with respect to the target duration. If handedness plays a significant role in timing, this may indicate differences between hemispheric functioning as a possible causal mechanism. If there is cerebral asymmetry in time perception, namely if one hemisphere is more competent regarding time perception, accuracy in judging duration should be higher for the contralateral hand. The results of the present study indicated that there are no significant differences in performance between right-handed and left-handed participants, or between male and female participants, in the estimation of short intervals of time.

This work is dedicated to my source of inspiration for everything I do:

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INTRODUCTION

Estes (1974) notes that interest in the phenomena of time has a lengthy history and particularly in psychology, the phenomenological aspects of time have been of interest and time perspective has been considered from a number of theoretical positions. Psychologists have been highly interested in what is referred to as the “time sense” (Wallace & Rabin, 1960). This concept has been used extensively and has acquired a large number of definitions: time perspective, time orientation, and time perception, among them. The majority of the experimental work in the area of time perception has dealt with time estimation (Fraise, 1984), and the concept of time perspective (Zakay, 1990) is considered as a possible dimension of temporal experience.

Marmaras, Vassilakis, and Dounias (1995) propose that a specific area, where the ability to estimate time may be significant, is in the performance of work tasks. One key component in the designation of work is designing schedules and procedures in terms of time intervals during which predetermined actions must be performed by the worker. These can be anywhere from a period of seconds to several hours. In these situations, concurrent tasks may be required and in most situations, a time signal or device may be unavailable or ignored. Under these circumstances, the accuracy of time estimation by the human operator is critical for the performance of the work system and is also an important component for human reliability and system safety (Decortis & Cacciabue, 1988).

Someone who can perform a complex task, such as juggling, data entry, doing secretarial work, flying an aircraft, or engaging in industrial inspection and assembly, needs to be able to effectively estimate the timing of a number of ongoing activities. However, people do show considerable differences in their efficiency with time. Some of these differences may possibly result from differences in a basic ability to perceive and estimate time intervals (Wickens, 1992).

The practical implications of research and theory on time perception are as numerous as the cases in which a human operator is expected to keep track of time while performing a task. These may include: (1) the pilot of the high performance aircraft who is required to perform a variety of tasks; (2) the process control or nuclear power plant monitor who is deciding, remembering, and scanning to acquire new information; (3) the musical performer who must attend to notes, rhythm, accompanist, and the quality of her or his own performance; (4) the vehicle driver who must drive safely while operating a radio or other device and attend to traffic and other stimuli from the environment; or (5) the learner of any skill who perceives different stimuli associated with a task, make responses, and process feedback (Wickens,1992). All of these activities require decision-making, actions, and reactions based on the operator's ability to perceive the passage of time and determine the appropriate action in response to time.

Time-linked work, such as on an assembly line, poses a particular problem, specially when the job is repetitive, time driven, and calls for constant alertness. Some jobs in industry and transport, such as driving and flying, call for sustained alertness, which is specially demanding mentally. Mental activities rely on external information supply and on the use of short and long-term memory to make decisions. Proper timing on the part of the operator is essential to avoid overloads and to facilitate correct and effective actions (Kroemer & Grandjean, 1997).

Time is information required by humans for orientation in their surrounding world. Time is a systematic tendency, an organization of mental representations, the way by which people give order to their experiences (Michon & Jackson, 1985). People are required to manage time and the notion of time is required for dealing with the phenomenon of change. Psychological or subjective time derives from two sources: from various changes and motions in the world and from inner experience. These two sources suggest that time provides a link between the mental and physical worlds (Denbigh, 1981). To explore one possible element of this link, the purpose of this study was to investigate the relationship of hand preference (an element of inner experience) to the estimation of time intervals (changes in the world). Halpern (2000) reviewed a large body of research literature, which documents the finding that left-handers differ from right-handers on some cognitive abilities. The present study investigated time perception as one of those potentially differing cognitive abilities between people with different hand preferences.

Theoretical Framework

Theories of Time

The development of psychological theories of time has provided two possible explanations: the cognitive and the biological (Estes, 1985). Cognitive theories (Ornstein, 1969; Fraise, 1963; Schiffman & Bobko, 1974; Zakay, 1989, 1992) suggest that psychological time is a product of information-processing events, especially those involving memory, attention, and judgment. On the other hand, biological theories (Bunning, 1964, 1973; Dimond, 1964; Braitenberg & Onesto, 1960) propose that psychological time is a product of brain mechanisms that involve some form of internal clock by which an individual is able to judge duration.

The cognitive theories (Ornstein, 1969; Fraise, 1963; Schiffman & Bobko, 1974) expect the estimated duration of a given interval to become shorter with increases in the demands of simultaneous activities. The experience of time passing is then an inverse function of the processing required by a simultaneous task.

On the other hand, the biological theories have assumed certain physiological processes that function as an internal clock mechanism by which an individual is able to judge duration.

These physiological processes may include such elements as a time base, a counter, and a response translator. Time estimation then functions on an internal time base, which accumulates pulses (or subjective time units). The time base transmits the pulses to a counter. Pulses accumulate in this internal counter, which stores the subjective temporal units until the conclusion of the interval. From the counter the pulses are transferred to a comparator or translator, which translates the subjective temporal units into conventional time units (Hicks, Miller, Gaes, & Bierman, 1977).

Sex Differences

Maccoby and Jacklin (1974) state that differences in cognitive performance can be found between the sexes and that these sex-related differences are a known result from genetic, neural, hormonal, and sociocultural influences. A major theory of sex differences in brain organization concerns the possibility that female and male brains differ in how the two hemispheres are specialised for different tasks. Maccoby and Jacklin (1974) reported three primary areas in which sex-related cognitive differences are well established: spatial visualisation, verbal skills, and specific aspects of mathematical skills.

Given that the types of abilities that differ by hemisphere of specialization are the same ones that differ by sex, it seems probable that the sexes differ in the way their hemispheres specialize these abilities (Halpern, 2000). Because sex differences are primarily found with verbal and visuospatial tasks and because hemispheric specialization differs with respect to these two abilities, there seems to be evidence for sex differences in cerebral lateralization. Researchers have considered the possibility that sex differences in cognitive abilities may in fact reflect sex differences in the underlying neural structure or organization of the brain (Halpern, 2000).

Block, Hancock, and Zakay (2000) additionally reported differences between men and women in temporal cognition. Research in the field of time perception provides evidence that women make relatively larger and more variable estimates of duration than men do. Women either underestimate durations more often than men do or tend to estimate a subjective duration that is longer than the objective duration, while men do not significantly do so. Study design and other influences may affect the presence or absence of sex differences. For example, in time estimation, sex differences may be a result of the sensory modality tested, the time of day, ego strength, and the presence or absence of light (Block, Hancock, & Zakay, 2000). In general, the literature has argued that there are in fact sex differences in both the magnitude and variability of duration judgments.

Handedness

Handedness can be defined and measured in two separate ways: preference and skill (McManus & Bryden, 1992) both reflecting the degree of handedness and the direction of handedness. Preference refers to the participants' hand preference in carrying out everyday tasks, such as handwriting, and is usually assessed by self-report in questionnaire form. Skill refers to objectively determined performance differences between the two hands in tasks such as frequency of tapping, reaction time, or moving pegs around a board. Skill asymmetry is measured by comparing the ability of the right and left hands on the same task. The dominant hand is defined as the hand that is regularly used in tasks that require only one hand (Coren, 1992).

Handedness is important not only as a major neuropsychological phenomenon but also as a secondary variable for interpreting other processes (McManus & Bryden, 1992). Handedness demonstrates contralateral control, that is, the point of origin is the hemisphere opposite the dominant hand. Organic qualities of the hemisphere affords the dominant hand a greater measure of competence, precision, expression, or force than is afforded the other hand by its controlling hemisphere (Harris, 1992). Contralateral control in left-handers may help understand the relationship of laterality to cognitive, perceptual, and emotional development.

Left-handers are a known minority in the human population. Judging from depictions of hand use in works of art and from the analysis of the design of weapons, tools, and other historical artifacts, right-handers seem to have been the norm, and left-handers the minority, since prehistoric time (Coren & Porac, 1977).

Porac and Coren (1981) refer to The Right-Sided World Hypothesis, which observes that most tools, equipment, furniture, traffic patterns, and seating arrangements are designed for right-handers. This forces left-handers to live in a world of right-handed objects and customs, such as those found in office and school settings, namely school desks, spiral notebooks, writing instruments, scissors, pencil sharpeners, and rulers. This right-hand bias is also found in the kitchen, namely place settings, ice cream scoops, and can openers. And also in musical instruments, sporting gear, artists’ palettes, assembly lines, and power tools. And even in common objects such as wristwatches and cameras and common machinery, such as sewing machines, gearshifts, voting machines, slot machines, time-card punches, and candy and soft drink dispensers. There are even some beliefs and social customs that are almost exclusively right-handed, such as handshakes, oaths, and salutes.

Halpern and Coren (1990) propose that this right-handed design of the world may go beyond just inconvenience, and actually constitute a danger for left-handers. They suggest that handedness may have biological implications that result in a younger age at death for left-handers, so that left-handers may have reduced longevity relative to right-handers. Halpern and

Coren (1988, 1991) examined this relative difference in survival as a function of handedness. Their overall pattern of results suggests that left-handedness is associated with a somewhat earlier age of death. They conclude that left-handedness is associated with reduced longevity.

A possible explanation given by Halpern and Coren (1991) may be that left-handers are placing themselves at some risk when they are forced to use their nonpreferred hand when working with equipment designed for right-handers. For example, safety levers usually located on the wrong side for a left-hander would likely delay response time in an emergency. To conform to the operation of some machines, awkward positions may have to be adopted which may result in an increased number of accidents and mistakes. In industrial settings or in traffic, such an accident might be fatal, or lead to serious complications. Also, the cumulative effect of many small injuries might contribute to an accumulation of damage and dysfunction, which would in turn increase the risk of early mortality in left-handers (Coren & Halpern, 1991).

To investigate the implications of accidents to the mortality of left-handers, Coren (1989) examined the incidence of accidents in five categories of activity: accidents when using tools or implements, while driving, in the home, in the workplace, and in sports. The results showed that left-handers are at increased risk of accident related injuries for all five categories of accidents, and in fact, left-handers are nearly twice as likely as right-handers to sustain accident-related injuries.

Although the design of environments may facilitate the use and comfort of right-handed users, it may very well have direct negative implications for the comfort, efficiency, and survival of left-handers. The typical patterns of left-handed behavior do not fit in with the requirements of the right-sided world, and this places them at a higher risk of accidents.

Because left-handers are reported to differ from right-handers in certain cognitive abilities and tasks and to be more frequent in certain clinical and special populations, the understanding of left-handedness may be the key to understanding the relationship of laterality to cognitive, perceptual, and emotional development (Harris, 1992).

Theoretical Foundations

Practical applications

The results of this study can be used to show the importance of using hand preference in the assignment of work tasks. If handedness is crucial in estimating time, this could be tested first. Employers could confirm if employees are right-handed or left-handed and this could be a factor in who to assign to a job where estimating time is a crucial part of the task. The possible application to follow is to improve performance and safety by either not placing left-handers in those positions, or taking handedness into consideration when designing or redesigning a task.

Purpose

The purpose of this study was to compare gender and handedness to the ability to estimate time intervals. With that goal, the primary purpose of this study was to determine empirically whether individuals of different handedness have different views of time. Experimental psychology is concerned with the study of subjective time but in spite of many efforts, the results are not very encouraging because many conclusions are contradictory, several areas of the problem have remained unexplored, and a complete and conclusive psychology of time estimation has not been achieved. The secondary purpose of this study was to extend the methods as reported in the literature to a sample of a normal, functioning population in an effort to evaluate how different handedness groups view and estimate time and to show that the ability to estimate time is affected by hand preference. The population for this study was undergraduate students from the University of Central Florida and the data was collected in fall of 2004 and spring 2005.

Significance of the present study

In view of the confusing results and the many deficiencies of the above-mentioned studies on the factors affecting time estimation, a further investigation of an additional factor was undertaken. It was anticipated that insights could be gained concerning the following aspects of this general problem: the consistency of time judgments and the effect of the relationship between hand preference and the length of the interval on this consistency; the influence of hand preference on the estimates of time intervals in terms of the average error (accuracy) and the constant error (over and underestimation of the intervals); the difference between right- and left-handers concerning time judgments; the relationship between handedness and accuracy, or a tendency to over or underestimate time; the relationship between hand preference and the length of the interval; and, the variability between right- and left-handers as far as time estimations are concerned.

If some evidence could be obtained in favor of the hypothesis that hand preference in some way affects time estimation, this would be a useful contribution to the field of psychology and the understanding of the processes involved in time estimation. This would contribute to the further understanding of factors and variables involved in time estimation, and thus help unravel this very complex psychological puzzle. This could shed some light on the general question of hand preference with reference to the ability to estimate time.

In addition, the results might also find a useful application in legal psychology, where differences in estimating time intervals may be often crucial in testimony. When jurors have to determine the reliability of an eyewitness account, the duration estimates presented by the witness may be used by the jurors as an indication of the reliability of the witness recollection (Loftus, Schooler, Boone, & Kline, 1987). It could also be helpful in abnormal psychology, where disturbances in the experience of time (time agnosia) are a frequent symptom in mental disease. For example, Krus and Fletcher (1986) report the finding that schizophrenics underestimate time. The study of temporal phenomena has been pursued in the area of abnormal behavior; considerable clinical data and observational reports concerning the disturbance of time experience in mental disorders have been suggested (Kinsbourne, 1972; Kinsbourne & Hicks, 1990; Schilder, 1936).

Hypotheses

If handedness plays a significant role in timing, this may indicate differences between the hemispheres of the brain as a potential explanation. If there is cerebral asymmetry in time perception, namely if one hemisphere is more competent regarding time perception, accuracy in judging duration should be higher for the contralateral hand. Therefore the following results were expected:

H1: Right-handed subjects will estimate time significantly more accurately than left handed subjects.

H2: Males will estimate time significantly more accurately than females

H3: Subjects using their preferred hand will estimate time significantly more accurately than subjects using their nonpreferred hand.

Definition of Terms

For the purpose of the present study the following terms will be used in context according to the following definitions.

Brain lateralization - the two hemispheres or halves of the brain are specialized or dominant for different cognitive functions (Halpern, 2000).

Conventional time units - are found in time measured by the clock, such as: hours, minutes, and seconds (Norman, 1992).

Counter - a regulatory component, which stores the subjective temporal units until the conclusion of the interval (Hicks, Miller, Gaes, & Bierman, 1977).

Dextrality - preference for using the right hand, the state of being on the right-hand side, the quality of being right-handed; right-handedness (Annett, 1998).

Duration – concept that applies to the interval between two successive events (Fraisse, 1984).

Interval sense – interval timing or the ability to measure intervals of time and to store representations of such intervals in memory (Hoerl & McCormack, 2001).

Logarithmic progression - a progression in which the terms increase or decrease by equal ratios, a progression is a finite sequence.

Nontemporal information - information regarding the stimulus or environment.

Physical time - an invention of technology, an arbitrary quantity based upon counting some recurring physical event (Norman, 1992).

Psychological time - experienced or subjective time where the sense of duration is independent of external markers such as clocks, calendars, or cycles and is dependent on internal events, which may be biological or cognitive (Estes, 1974). A personal experience, dependent on how the subject interprets the events (Norman, 1992).

Real time - the duration of a physical event (Norman, 1992).

Response translator - maps the contents of the counter onto the response surface, usually conventional time units, these time base pulses can be used as a basis for temporal judgement (Hicks et al., 1977).

Storage – term used in memory to refer to information that is encoded and retrievable.

Subjective temporal units - units based on an average mental content per unit of duration, the number of mental events experienced during an interval is the basis of the observer's judgement.

Temporal information – the temporal structure between the organism and the temporally organized environment, such as rhythm perception and the adaptation to sustained external periodicities (Estes, 1985).

Temporal perspective - refers to how a person construes and experiences the past, present, and future. It refers to the span of awareness into the past and future as well as the relative attention given to the past, present or future (Zakay, 1990).

Temporal schemata – internal representations of reality.

Time - the measurable aspect of duration, the objective basis of the characteristic of duration, the subjective experience of duration of a physical event, how long it appears to take (Norman, 1992).

Time base - a physiological process responsible for subjective temporal units, a generator of temporal impulses or intervals (Hicks et al., 1977).

Time interval – the period of time between two stimuli, the time period that separates two events (Block, 1990).

Time perception - the awareness of duration and the perception of the passage of time.

REVIEW OF LITERATURE

The present study examines the relationship between hand preference and accuracy of estimation of time intervals. Towards this purpose, the following topics concerning time perception will be considered: factors affecting time estimation, the nature of time intervals, concerns related to time estimation and handedness, sex differences in time estimation and handedness, and handedness and brain lateralization. All of these will be discussed in the present chapter.

Time Perception

The terms perceived, internal, subjective, psychological, and apparent duration (time) are used interchangeably. Generally speaking, they refer to the temporal value used by the subject in making a judgment about the passage of time (Allan, 1979).

The temporal analysis of information is one of the basic mechanisms of cerebral function. The central nervous system continuously receives information that needs to be analyzed both spatially and temporally for an adequate perception of the environment (Artieda & Pastor, 1996). In comparing time estimation to space perception, when perceiving space, cues are found to be immediately and sensoriably available to the perceiver, whereas in time estimation there is distinct dependence upon memory. Time estimations are made in retrospect and are thus dependent upon the memory of events occurring during the time interval. The expending of effort will give rise to feelings of duration.

No sense or sense organ by which time can be perceived directly is known, nor is it clear what information humans utilize to make time estimates (Zakay, 1990). Sensing the passage of time is not a single, independent function but arises from multiple feedback as the organism responds to both the internal and external environments. The way humans organize and interpret these experiences shapes their perspective of time.

Two cognitive models endeavor to explain the field of psychological time. One model states that temporal judgments are by-products of nontemporal information processing (Ornstein, 1969). These judgments depend on the number and the complexity of the information processed during the to-be-estimated period and subsequently stored in memory. The more number and complexity increase, the more subjective duration lengthens. The second model emphasizes the role of attention rather than memory and provides opposite predictions. Estimating the duration of a given period and processing nontemporal information during this period are viewed as two independent tasks that compete for attentional resources (Zakay, 1990). Time estimation would rely on internal accumulating pulses, or subjective time units, during the relevant period. The length of a temporal estimate would be positively correlated with the number of pulses recorded. A certain number of pulses would be lost each time attention is detracted from the timer and focused on nontemporal processing. With more numerous or complex nontemporal information, a greater amount of pulses would then be lost and a shorter temporal estimate would be produced (Zakay, 1990).

Human mental activities depend on temporal direction and time estimation is a deliberate process that involves selective attention and memory (Michon & Jackson, 1985). Information is transitorily stored in short-term memory, and then analyzed and synthesized by the central nervous system. Thus, temporal information is processed in the same fashion as nontemporal information. Since processing capacity is limited, the two types of information may be competitive. Subjective time is then reduced when the processing of temporal information is sacrificed in favor of nontemporal information (Estes, 1974). If during the interval, the experienced duration tends to increase with an increase in attention to time, then it can be expected that decreased attention to time due to the concurrent processing of nontemporal information should in turn decrease the experience of the duration. (Hicks et al., 1977).

Theories of time

Two possible explanations have been provided by the development of psychological theories of time: the cognitive and the biological (Estes, 1985).

The cognitive theories (Ornstein, 1969; Fraise, 1963; Schiffman & Bobko, 1974) expect the estimated duration of a given interval to become shorter with increases in the cognitive demands of concurrent activities. The experience of time passing is then an inverse function of the processing demanded by a concurrent task. A number of models have been developed to explain these findings. The shared-attention model (Hicks et al., 1977; Hicks, Miller, & Kinsbourne, 1976; Thomas & Cantor, 1978) explains that when participants confront a dual task, they share attention between temporal and nontemporal processing. When nontemporal demands increase, less attentional capacity is allowed to temporal processing, and judgements of duration become more unreliable. In the storage-size hypothesis (Ornstein, 1969), the more information that is stored, the greater is the storage space utilised and the longer the interval seems to have been. The attentional-effort model (Underwood & Swain, 1973) explains that judgements of duration are controlled by the attentional effort involved. The contextual-change model (Block, 1978, 1989) expects judged durations to increase as a function of the number of changes occurring in both the environment and in the organism. The dynamic attending model (Jones & Boltz, 1989) assumes that the structure of events provides two modes of attending: future oriented and analytic. Future oriented mode is based on anticipatory behaviors so that judgement of time is influenced by the way an event confirms or violates temporal expectancies. The analytical attending mode suggests that while other activities occur, judgements of time depend on the amount of attention given to the situation.

On the other hand, the biological theories have assumed certain physiological processes that function as an internal clock mechanism by which an individual is able to judge duration. These physiological processes may include a time base, a counter, and a response translator. Time estimation relies on an internal time base accumulating pulses (or subjective time units). The time base produces pulses and transmits them to a counter. Pulses accumulate in this internal counter, which stores the subjective temporal units until the conclusion of the interval. From the counter the pulses are transferred to a comparator or translator, which translates the subjective temporal units into conventional time units allowing for the perception of time (Hicks et al., 1977).

Michon (1967) theorised that this time base may be related to different physiological processes, such as: metabolism, heart rate, respiration cycle, alpha rhythm, cerebral processes, cerebellar processes, the sensorimotor feedback cycle, or neural scanning, among other possibilities. Because these physiological processes are known to vary between the genders, these physiological gender differences may directly affect the relationship between gender and time estimation.

Factors influencing time estimation

The study of time estimation attempts to determine the many cues, factors, and variables, which affect time estimation. Some of these reported factors are the length of time interval, the attitude of the subject, physiological factors, and the subject's background.

The intervals used in the experimentation on time estimation range anywhere from short to long, from milliseconds to several minutes. Dobson (1954) states that the length of the interval can possibly exert a significant influence on the estimation of time both in terms of accuracy and constant error, due to the fact that the estimation of different lengths might be mediated by different mechanisms of time evaluation. How exactly the length of the time interval affects time estimation is still an unanswered question. Although some evidence exists that there is a tendency for less accuracy with increasing time intervals (Dobson, 1954).

The attitude of the subject is critical; attitude could mean any subjective condition of the individual as time is being estimated, such as attention, motivation, expectations, tension or stress. Woodrow (1933) described the importance of the subject's attitude by stating that the activity shortens or lengthens the interval according to whether the subject's attention is on the activity itself or on the duration.

Physiological factors also influence the process, whenever duration is experienced and evaluated indirectly, as happens with long intervals, the subject has to rely on cues of different kinds. It is possible that some of the cues may be of physiological nature (Michon, 1967). Such internal physiological processes as pulse, heart rate, breathing rate, blood pressure, and temperature may furnish some kind of cue for time estimation.

The subject's background is another crucial factor in time estimation. Several identifying factors, such as age, sex, culture, occupation, and mental health, have been proposed in the research as having a direct influence on the participants' ability to estimate time (Bell, 1966; Bell & Watts, 1972; Zakay, 1990).

A study that examined gender differences in time perception was conducted by Hancock, Arthur, Chrysler, and Lee (1994) with 12 participants (6 female and 6 male) in which they explored the effect of the level of illumination on the ability to estimate short intervals of time. The participants made estimates of 1, 3, 7, and 20 second intervals with 60 trials per duration, half with the lights on and half with the lights off. The results showed that females produced significantly less variable responses in light compared to the dark condition. Women reduced their variability in lighted conditions while men showed no change in variability as a function of lighting.

Nature of time intervals

Hicks, Miller and Kinsbourne (1976) define two types of time intervals: filled and unfilled intervals. Empty or unfilled intervals are those where no concurrent activity is taking place, hence processing of information or stimulation is not required of the subject. Filled intervals are those where the processing of nontemporal information is required, when the subject must process the stimulation presented or perform some concurrent task during the interval.

Common methodological procedures used in time measurement

In time studies participants have to estimate the duration of a completed time period by relying on memory, either prospectively (having been instructed to attend to time) or retrospectively (having been unaware that they would be required to attend to time) (Hicks, Miller & Kinsbourne, 1976). In general the experience of passing time (experienced duration) is influenced by what else is being done at the time. Indeed, many studies have corroborated the view that in prospective timing, time appears to pass more rapidly when engaged in a higher level of behavioral activity (Vroon, 1970; Hicks, Miller, Gaes, & Bierman, 1977). On the contrary, a low level of behavioral activity results in the impression that time is dragging, which causes the experience of boredom. Yet, these effects are reversed in retrospect (remembered duration). A period devoid of interesting events is estimated as having had a very short duration if one looks back on it, while the retrospective temporal estimate of interesting events is that of a long duration (Ornstein 1969; Vroon, 1970).

In the study of temporal phenomena, the method by which the study is conducted has a direct influence on the outcome. According to Bindra and Waksberg (1956) there are four main methods used in the research of time estimation: the method of estimation, the method of production, the method of reproduction, and the method of comparison. Each of these methods presents characteristic features. All these methodological procedures involve mechanisms, which are used in daily life in the perception of time (Artieda & Pastor, 1996). Through these methods it is possible to obtain an estimation of the accuracy of the judgments (average error) and an estimation of the direction of the error (constant error) in terms of over or underestimation of an interval. Following is a description of each method as found in Bindra and Waksberg (1956) and in Hornstein and Rotter (1969):

In the method of estimation the subject is asked to evaluate in terms of a time unit (second, minute, or hour) an interval which was demonstrated operatively by the experimenter. In this method, the interval is estimated after it has passed therefore, recall is an important element of the process of time estimation, and memory works retrospectively.

In the method of production the subject is asked to produce operatively an interval of the length specified by the experimenter. In this method, the subject is estimating time while it is passing, therefore recall does not play an important role, and memory works prospectively.

In the method of reproduction the subject is asked to reproduce operatively an interval, which was previously operatively delimited by the experimenter.

In the method of comparison the experimenter presents operatively two intervals and the subject is asked to compare their relative duration as longer, shorter, or equal.

Sex Differences in Time Estimation and Handedness

There is a continuing interest in the relationship among handedness, sex, and cognitive processes. Three patterns of results have contributed to this interest (Carter-Saltzman, 1979): (1) The disproportionately high incidence of males and left-handers or mixed handers in clinical groups of children with reading and learning disabilities, social cognitive disorders such as autism, and speech problems such as stuttering. (2) The finding that males and females may have different patterns of hemispheric specialization for cognitive functions and that these patterns may be related to handedness. (3) The frequently reported existence of sex related differences in adulthood on tests of spatial visualization (males perform better than females), visual memory tests (females perform better than males), and handedness (more left-handed males and/or more ambidextrous than females).

The combined results of numerous studies indicate that males and females do perform differently on certain types of cognitive tasks (Halpern, 2000; Block, Hancock, & Zakay, 2000; Hancock, Vercruyssen, & Rodenburg, 1992). One possible explanation for this finding is that there is a sex-related difference in the organization of higher cortical functions, expressed behaviorally as a sex-related difference in cognitive abilities. Evidence from studies of laterality in normal participants indicates that there may actually be a sex-related difference in cerebral organization; thus, certain sex-related differences may be due to fundamental differences in neurologic organization (Halpern, 2000).

Additionally, research has shown sex-related differences in the effects of cerebral damage. McGlone (1980) found a greater verbal IQ deficit in males with left hemispheric lesions relative to females with similar lesions and to participants of either sex with right-hemispheric damage. Lansdell (1961, 1973) reported that males show a greater impairment than do females on tests of verbal ability after damage to the left hemisphere. Males also show a greater deficit than do females on tests of performance IQ or visuospatial ability following right-hemispheric damage. Lansdell and Urbach (1965) reported that the differing effects of right and left hemispheric damage are greater in males than in females. Similarly, McGlone (1980) found that the side of damage affects the difference between verbal and performance IQ only in males.

The study of duration judgment processes illuminates other general cognitive processes, such as attention and memory. Although it is difficult to predict a pattern of sex differences involving memory and cognitive processes, Block, Hancock, and Zakay (2000) report that several such differences have been found in the literature. Females, in general, perform relatively better on tasks that involve production and comprehension of complex prose, fine motor skills, and perceptual speed, while males perform relatively better on tasks that involve visuospatial transformations, spatiotemporal operations, and fluid reasoning (Halpern, 1997).

There are reported sex differences in temporal cognition, and the nature of the differences has been shown to depend on how they are measured. When the task involves a verbal response, females give longer estimates than do males, but when the response requires producing a time interval, females produce intervals that are shorter than those produced by males (Hancock, Arthur, Chrysler, & Lee, 1994; Zakay & Block, 1997). Block, Hancock, and Zakay (2000) concluded that there are reliable differences, albeit small, in the way females and males judge time in passing. These differences are moderated by many variables, including the way in which time judgments are assessed (Bindra & Waksberg, 1956).

Handedness and Brain Lateralization

Halpern (2000) reviewed a large body of research and concluded that the two hemispheres or halves of the brain are, to some extent, lateralized or dominant for different cognitive functions. Halpern (2000) proposed the cognitive style theory to explain that lateralization appears to provide for a minimization of interference effects in neural activity patterns and a maximization of the integration of these patterns. If two very different kinds of cognitive capacities are to be present, then joint optimization of the level of these capacities seems to require lateralization. Lateralization of function suggests that the component tasks that underlie complex cognitive feats, like understanding or producing language, are handled with different degrees of speed and ease by each hemisphere (Halpern, 2000).

Human beings are distinguished from all other animals not only by their capacity for speech, but also by usually preferring to use the right hand for precision tasks. No other species shows a consistent preference for using one limb rather than the other. This preference for the right hand probably evolved because highly skilled movements could be successfully developed only by confining the neural brain pathways required to control them to one hemisphere (Stein, 1988).

Better understanding of how handedness relates to brain function is relevant to many people, among them: academic and clinical researchers, medical clinicians, neurological patients, educators, and left-handers. Clarifying the relationship between handedness and functional brain specialization, and learning more about the developmental and neurobiological mechanisms that underlie these relationships, may help better understand a wide range of issues such as dyslexia, stuttering, human variation, comparative brain research, developmental neurobiology of the brain, and the origins of human language.

Handedness is important in that it serves as a potential neuropsychological marker of underlying brain development and may also reflect the manner in which cognitive functions are localized to the left or right cerebral hemispheres (O'Boyle & Benbow, 1990). This proposed link between brain function and hand dominance provides reason to research the fact that hand preference may systematically relate to individual differences in cognitive tasks. One of these tasks may be time estimation.

Handedness can be defined as the preference shown by children and adults for left versus right hand use in unimanual tasks. A variety of instruments have been developed to measure this preference, with the Edinburgh Handedness Inventory being the most widely used (O'Boyle & Benbow, 1990). The Edinburgh has been shown to have high internal consistency (Williams, 1991).

Stein (1988) argued that during the first half of the 20th century there were essentially two opposing positions regarding the origins of human manual asymmetry. Some investigators proposed that the direction of hand dominance was solely a consequence of sociocultural conditioning; others attributed part of the variation in handedness to genetic variation and part to sociocultural factors. The environmental school (Barsley, 1966) attempted to demonstrate that the degree of pressure exerted on children to be right-handed was related to the proportion of dextrality in the population, and the genetic school (Corballis & Beale, 1976) sought to prove that there were various asymmetric traits present in the neonate that were predictive of handedness. The evidence shows that a combination of both prenatal and postnatal factors affects the direction of manual dominance (Stein, 1988).

Coren (1992) explains that manual performance has been used to assess asymmetries of hemispheric function. The hemisphere contralateral to the side of the acting hand primarily controls unilateral motor performance. To assess this, participants are asked to perform a simple motor task, such as balancing a dowel or tapping with a stylus, and participants are then asked to perform a simple cognitive task such as humming or reciting simultaneously with the motor task. The extent to which concurrent cognitive activities interfere with unilateral motor performance is taken as a measure of lateralization for particular kinds of cognitive functioning. For instance, if a subject were to show a greater decrement in dowel-balancing performance with the right hand rather than the left hand while reciting a poem, the subject would be inferred to have left hemispheric predominance for verbal recitation processes.

The most consistent difference between individuals is which hand one uses, and there are quite clear and consistent brain differences for both sexes. Coren (1992) notes that human beings strongly favor the right hand (90%), foot (80%), eye (70%), and ear (60%). Females are slightly more strongly right sided: 90% of women are right handed, while only 86% of men are. Damage to the right hemisphere of women generally interferes less with spatial, emotional, and social functions than does comparable damage to the right hemisphere of men. The reverse is true for language and related functions: more women with left hemisphere damage can speak well that can men with similar damage (Ornstein, 1977). These differences are consistent between men and women.

There is a substantial difference in brain organization between right and left-handers (Ornstein, 1977). Scales are used to measure how strongly right-handed or left-handed people are. Some people write, paint, kick, throw, or gesture exclusively with their right side, and others may write right-handed but kick left, or throw left, or draw left. The difference in the sides indicates that people have different kinds of hemispheric organization. About 90% of right-handers are typical in their cerebral organization, while only 66% of left-handers are (Ornstein, 1977), thus not everyone has the standard differences in the two sides of the brain. There are differences between males and females, and between right- and left-handers. As a matter of degree, some people are highly divided and others are more integrated. The differences in brain lateralization have been shown to be more prominent between left- and right-handers than between men and women (Ornstein, 1977).

Although the brain appears symmetric, extensive research has indeed shown that each side of the brain controls different functions. The left half of the cortex receives sensory information about the right half of the world, and it controls the motor responses on the right side of the body. Sensory information and motor control for the left half of the world are under the control of the right hemisphere (Halpern, 2000). Thus, brain mechanisms for sensory input and motor output are under contralateral (opposite side) control. Because the right hemisphere controls the movements of the left side of the body and the left hemisphere controls the movements of the right side of the body, most right-handers have dominant motor control in their left hemisphere, and most left-handers have dominant motor control in their right hemisphere. Hand differences are of particular interest in the study of brain organization because preferred hand use is an indirect index of lateralization of brain dominance (Halpern, 2000).

The differences that are found between right- and left-handers in cognitive abilities are known to be lateralized in the right or left hemisphere. Halpern and Coren (1990) state these differences would create at least two possibilities for left-handers: overall poor performance by left-handers on cognitive tasks that are associated with the left hemisphere, and/or exceptionally high performance on cognitive tasks that are believed to be primarily under right hemisphere control.

A goal of handedness research has been to determine whether having a left hand attached to a hemisphere with different functional skills than the hemisphere attached to the right hand means differences in the behaviors of left- and right-handers. In left-handed people brain organization is often different from that of right-handed people and there are well-documented differences between right- and left-handers in the lateral organization of higher cognitive functions in the cerebral cortex (Harris, 1992). The present study will examine if this poses an additional difference in one specific cognitive function: the ability to perceive time in right- and left-handers.

EXPERIMENTAL METHODS

This investigation was undertaken with the purpose of studying the bearing of hand preference on the estimation of time intervals. To achieve this purpose, it was necessary (1) to select a method of time evaluation, (2) to select the appropriate time intervals, and (3) to include a sample representative of both handedness groups: right- and left-handers. All of these procedural questions will be discussed in the present chapter.

Participants

Thirty-two adults participated as volunteers in this study. Participants were students at the University of Central Florida. All were in professed good health at the time of testing and they ranged from 18 to 24 years of age, with a mean age of 20.125 years. Each of two groups, 16 males and 16 females, were comprised of equal numbers of right-handers (8) and left-handers (8). One female researcher collected all experimental data. Professors of psychology at the University of Central Florida were asked to read an announcement to their classes about the present study, including an explanation of the study, its purpose and the possible roles of the participants. The announcement asked students to visit a website to take the Edinburgh Handedness Inventory online. The website provided their scores and those individuals who scored as either strongly right-handed (+18 to +20) or strongly left-handed (-18 to –20), were then contacted and asked to come in to the psychology department offices at the University of Central Florida to participate in the one-on-one experiment about time estimation. All four groups (female and male right-handers, and female and male left-handers) had the same mean score of 18.625 on the Edinburgh Handedness Inventory.

A total of 1,276 individuals completed the online questionnaire. Of these, 935 were female and 341 were male. Of these, only 19 females and only 17 males scored as strongly left-handed in the online Edinburgh Handedness Inventory (-18 to -20). Contact was attempted with all of them, and 8 participants of each sex were able to participate and were included in the present study.

Apparatus

The apparatus was a response metal box with two buttons, one to start and one to stop a millisecond timer. The response box was wired to a digital timer at the experimenter's station. The buttons on the response box gave the participant the means to estimate the requested time interval. The participant pressed the start button to mark the beginning of the interval and pressed the stop button to indicate when the estimated time interval had been completed. The experimenter then noted the estimated time as recorded by the digital timer for each trial.

Instrumentation

Handedness was measured using an online adaptation of the Edinburgh Handedness Inventory (Oldfield, 1971), a handedness assessment questionnaire to evaluate to what extent the participants were dominant in their use of either the left or right hand. Tests such as the Edinburgh Handedness Inventory are designed to obtain information about hand preference. The degree of a subject's left- or right-handedness can be found by using the results to compute a laterality quotient, which shows a range from complete right-handedness (+20), through ambidexterity, to complete left-handedness (-20).

The present study used the Edinburgh Handedness Inventory as a screening device to determine strong right- and left-handedness. This handedness questionnaire was adapted from

Oldfield (1971). The Edinburgh Handedness Inventory was developed at Edinburgh University by R. C. Oldfield (1971). Oldfield (1971) proposed the Edinburgh Handedness Inventory as a simple and brief method of assessing handedness on a quantitative scale for use in clinical and experimental work. It is based on answers to questions about the participants' practice in performing a number of every day activities in which hand preference is distinguished.

The questionnaire consisted of a list of ten activities (see appendix A) and participants were asked to indicate their preference in the use of hand for each one. Participants were asked to indicate which hand they prefer to use to perform such simple tasks as writing, using a spoon, using a toothbrush, and opening a box lid.

The score was determined by hand preference and strength of that preference. In the first column, participants indicated their hand preference for each activity (R for right-handed or L for left-handed) and strength (+ or ++) by indicating if they ever use the other hand or not for each activity. The total score is the sum of one point for each R answer and a minus one for each L answer. An additional point was given for each activity if participants indicated never using the other hand. For the list of ten activities, the maximum possible score is 20 points. The scores range from +20 (completely right-handed) to -20 (completely left-handed). For the purposes of the present study, individuals scoring from +18 to +20 were considered strong right-handers and individuals scoring from -18 to -20 were considered strong left-handers. These participants qualified to participate in the time estimation task. Participants were subsequently grouped according to gender and preferred hand use based on their score on the handedness questionnaire.

Environment

The participants were seated at a table in a private room with the door closed. The sessions were conducted with only one subject at a time and in the same room with one female researcher conducting the experiment. On the table was the response box wired to a digital timer at the experimenter's station. Participants were free to move the response box on the tabletop in front of them so that it was in a comfortable position. Participants were asked to remove their watches or any form of timekeeper. (See appendix C).

Procedure

Participants were asked to sign a consent form (see appendix B). A written explanation of the procedures was given to each of the participants to read and a verbal review of the procedures followed. Then the response box was shown and its function and buttons were explained. To help them get acquainted with the response box and procedure, participants were given ten practice trials, without feedback, in which they were asked to estimate a ten-second period each time. Then following the signal to start, the participants were asked to press the start button to initiate the trial and the stop button to terminate it when they determined that their estimation was equivalent to the desired interval. Participants were asked to then pause before initiating the next trial. After completing the practice trials, participants were asked to estimate four time intervals using the two buttons on the response box, of 1 second, 3 seconds, 7 seconds, and 20 seconds in duration.

Participants were to estimate the requested time periods using the time estimation method known as the production procedure for empty intervals (Bindra & Waksberg, 1956; Clausen, 1950: Guay & Salmoni, 1988: Doob, 1971). Empty intervals are those where no concurrent activity is taking place, hence processing of information or stimulation is not required of the participant (Hicks, Miller & Kinsbourne, 1976). In the production procedure of time estimation the subject is instructed to produce an interval of a given duration as requested by the experimenter (Bindra & Waksberg, 1956). That is, the subject must translate a verbalized interval into a physical one.

The following order of presentation of the different time intervals was randomized by participants. In the first procedure, participants were asked to produce 40 consecutive 1-second intervals with the start and stop buttons on the response box. Second, participants were asked to produce 40 consecutive 3-second intervals using the two buttons on the response box. Third, participants were asked to produce 40 consecutive 7-second intervals using the two buttons on the response box. Last, participants were asked to produce 40 consecutive 20-second intervals using the two buttons on the response box. For each of the four time intervals (1, 3, 7, and 20 seconds) the forty total trials were divided into four blocks of ten trials each. The first two blocks of each time interval were always conducted with the participant's preferred and, the last two blocks were then conducted using the participant's nonpreferred hand.

Participants completed forty consecutive trials at one of the intervals before proceeding to the next interval. The order of presentation of the different time intervals was randomized, except that orders were matched across sex such that one male and one female were yoked with respect to a particular presentation order. Participants were told to change to an alternative interval only on completion of each block of forty trials. Participants were also asked to pause briefly during the change over from one interval to the next.

Following each trial, the experimenter recorded on a personal computer the time estimation to the nearest millisecond. After recording each interval estimation the timer was reset by the experimenter. Participants were not given any feedback concerning their performance during the trials. The opportunity to take a break was offered to each subject following the completion of any of the block trials. Upon completion of the four sets of intervals (160 total trials) participants were asked to fill out an information sheet of their demographics and questionnaires about their attitudes and habits concerning time and temporal orientation.

Time Intervals

Within the domain of experimental psychology, the study of time has been defined as the psychophysics of duration. Which in turn has been defined as absolute thresholds (the minimum amount of time perceived as an enduring moment) and relative thresholds, which have been determined as a function of different physical, physiological, and cognitive variables (Michon, 1990).

Fraisse (1984) identifies three orders of duration on the physical continuum, characterized by stimulating different temporal processes: (1) less than 100 ms, at which the perception is of instantaneity, (2) 100 ms to 5 seconds, perception of duration in the perceived present, and (3) above 5 seconds, estimation of duration involving memory.

The chosen intervals for the present study of 1 second, 3 seconds, 7 seconds, and 20 seconds in duration are four target intervals representing a natural logarithmic progression (a progression in which the terms change by equal ratios) and a series that bracket temporal thresholds that have been proposed as important in the literature. Namely the range of the immediate present at 3 seconds (Poppel, 1988), the duration of conscious intention at 7 seconds (Iberall, 1992, 1995), and the boundary of brief intervals at 10 seconds (Allan, 1979). In addition the 20-second interval was included in this study as an extension of the natural logarithmic progression, 20 seconds being the next step of the progression.

Design

In the experimental design, there were two between-subject factors and two within-subject factors. The between-subjects factors were sex and handedness and the within-subjects factors were block and interval. There were two levels each of sex (male and female) and handedness (right- and left-handed). The forty total trials were divided into four blocks of ten trials each and the estimated time intervals were one, three, seven, and twenty seconds respectively. Dependent error measures were then derived from the participant responses. The dependent measure was constant error (CE), which represented the deviation of each score from the target interval. This measure provides a portrait of the individual's response in terms of variability and central tendency with respect to the target duration (Woodrow, 1934).

The research question refers to the comparison of left-handed and right-handed participants. For this reason, the comparison was done with t-tests, in view of the fact that that this study compares two groups on one score. Four t-tests were conducted, one for each time interval (1, 3, 7, and 20 seconds).

The results are presented as additive scores of the absolute values of the differences between the target duration and the estimated duration. This was done to provide more variability by adding the absolute scores, instead of finding the averages, to afford enhanced analysis of the data. In all cases, the score was found by subtracting the actual time from the time estimate (subtracting 1 from the 1-second, 3 from the 3-second, 7 from the 7-second, and 20 from the 20-second) and then taking the absolute value, and then adding them all together (not averaging them). That is, overestimates and underestimates were added together, independent of sign.

Sampling

The present study used the sampling technique of quota sampling. This is a sample selected by dividing the population into categories (right- and left-handers in this case) and selecting the same number of male and female participants from each category (Vogt, 1999). Individual participants within each category were not selected randomly, they were chosen on the basis of their hand preference as determined by their score on the Edinburgh Handedness Inventory.

Criteria for Inclusion

Criteria for inclusion in the present study were based on the specific scores of the Edinburgh Handedness Inventory taken online by the 1,276 volunteers. The measure is designed to determine hand preference. An equal number of male and female participants who scored 18 or higher, either positive or negative, qualified to participate in the time estimation experiment.

Data Analysis

The scores combine between-subjects factors, in which each subject is measured only once, and within-subjects factors, in which participants are measured repeatedly (Heiman, 1998). In the present study, there were two between-subject factors and two within-subject factors. The between-subjects factors were sex and handedness and the within-subjects factors were block and interval. There were two levels each of sex (male and female) and handedness (right- and left-handed). The forty total trials were divided into four blocks of ten trials each and the estimated intervals were one, three, seven, and twenty seconds respectively. The research question refers to the comparison of left-handed and right-handed participants. For this reason, the comparison was done with t-tests, and four t-tests were conducted, one for each time interval (1, 3, 7, and 20 seconds).

Assumptions

The present study assumes that the participants have been either right- or left-handed their entire lives, without societal pressures. This study also assumes that responses given to the Edinburgh Handedness Inventory online were true and candid and that the participants had no difficulty in answering the inventory online.

Limitations

The possible limitations of this study were as follows: the difficulty locating true and total left-handers; and the possibility that participants may use time estimation strategies, such as counting in their heads, even when asked not to. The shortness of the time intervals may be an additional limitation regardless of estimation strategies.

Research Questions and Hypotheses

First, how consistent are the participants in their time judgments? Do hand preference and the length of the interval, as revealed by the reliability of time judgments, in any way affect this consistency?

Second, does the subject’s hand preference significantly influence the estimates of time intervals in terms of the average error (accuracy) and the constant error (over and underestimation of the intervals)?

Third, is there any significant difference between right- and left-handers concerning time judgments? Does there exist a relationship between handedness and a more accurate feeling of time or a constant tendency to over or underestimate time?

Fourth, does the effect of hand preference on time estimation depend on the length of the interval?

Fifth, how do right and left-handers differ in variability as far as time estimations are concerned?

H1: Right-handed subjects will estimate time significantly more accurately than left handed subjects.

H2: Males will estimate time significantly more accurately than females.

H3: Subjects using their preferred hand will estimate time significantly more accurately than subjects using their nonpreferred hand.

RESULTS

Potential participants from the University of Central Florida were asked to visit a website to take the Edinburgh Handedness Inventory online. The website provided them with their scores and those individuals who scored as either strongly right-handed (+18 to +20) or strongly left-handed (-18 to –20), were then contacted and invited to participate in the time estimation study. Thirty-two adults participated as volunteers in this study. Each of two groups, 16 males and 16 females, were comprised of equal numbers of right-handers (8) and left-handers (8).

The participants were asked to use the buttons on the response box provided, which gave them the means to estimate the requested time interval. The participants pressed the start button to mark the beginning of the interval and pressed the stop button to indicate when the estimated time interval had been completed. The experimenter then noted the estimated time as recorded by the digital timer for each trial. After completing the practice trials, participants were asked to estimate four different time intervals using the two buttons on the response box, of 1 second, 3 seconds, 7 seconds, and 20 seconds in duration. Participants completed 40 consecutive trials at each one of the intervals before proceeding to the next interval, without feedback.

Table 1

Descriptive Statistics

	N	Minimum	Maximum	Mean	Standard Deviation
Sec 1 total	32	-16.655	44.699	2.009	12.921
Sec 3 total	32	-65.790	48.160	-18.38500	27.645660
Sec 7 total	32	-142.230	110.610	-20.73125	70.480489
Sec 20 total	32	-367.120	672.200	14.49656	247.094216
Total	32	-602.317	893.31	-45.0025	376.32667
Valid N (listwise)	32				

The results are presented here as additive scores of the absolute values of the differences between the time interval to be estimated, and the actual estimate given. This was done to provide more variability by adding the absolute variables, instead of finding the averages, to afford enhanced analysis of the data. In all cases, the score was found by subtracting the actual time from the time estimate (subtracting 1 from the 1-second, 3 from the 3-second, 7 from the 7-second, and 20 from the 20-second) then taking the absolute value of that, and then adding them all together (not averaging them).

The research question refers to the comparison of left-handed and right-handed participants. For this reason, the comparison was done with t-tests, in view of the fact that that this study compares two groups on one score. T-tests were also decided upon because they are also more workable with the sample size used in this study.

Four t-tests were conducted, one for each time interval (1, 3, 7, and 20 seconds). It is to be noted that there are no significant differences in any of the measures taken, the T-tests revealed no significant performance differences. In each case the p value shows there is no statistical differences in any of the means. The summary is that there is no statistical difference between left-handed and right-handed people on their overall scores.

Due to the number of t-tests conducted, a Bonferroni Adjustment was done which lowered the p value to .0125 so that the alpha level was adjusted downward to manage chance capitalization. However, in the results the adjustment was not necessary since none of the measures reached even the .05 significance level.

Table 2

Absolute Scores: Means and Standard Deviations on All Dependent Measures

	Right-handed		Left-handed			
Time Difference	M	SD	M	SD	t	p-value
Preferred Hand	138.304	85.91	153.378	85.72	-.49	.62
Nonpreferred Hand	160.461	125.13	138.694	54.14	.64	.53
1 Second	12.180	10.89	10.845	6.77	.42	.68
3 Second	26.791	15.01	33.070	17.13	-1.10	.28
7 Second	59.646	34.80	71.692	40.55	-.90	.37
20 Second	200.141	151.72	176.47	81.23	.55	.59
Totals	298.766	172.18	292.073	123.10	.13	.90

Table 2 includes the results for "Totals" which includes all categories added together; "Preferred Hand" and "Nonpreferred Hand" referring to the handedness preference of the participants; and the estimates for each time interval under 1 second, 3 seconds, 7 seconds, and 20 seconds.

Although no significance was found in the means, the standard deviation is found to be quite different as an indication of higher variability under certain circumstances. The standard deviations seem to be fairly different from each other in the following rows in table 2: Nonpreferred Hand, 1 second, and 20 seconds. In each case the standard deviation among the right-handed participants was found to be higher than for the left-handed participants. It can be noted that in all cases, the left-handed have lower scores than the right-handed. In the case of 1 and 20 seconds, this means being more accurate.

Table 3

Additive Scores: Means and Standard Deviations on All Dependent Measures

	Right-handed		Left-handed			
Time Difference	M	SD	M	SD	t	p-value
Preferred Hand	22.56	238.24	-25.57	258.01	0.55	.59
Non-Preferred Hand	15.02	177.82	-23.89	202.04	0.58	.57
1 Second	3.13	14.24	0.89	11.81	0.49	.48
3 Second	-14.63	26.98	-22.14	28.65	0.76	.46
7 Second	-17.38	65.63	-24.08	77.03	0.26	.79
20 Second	41.98	238.43	-12.99	260.23	0.63	.54
Totals	-6.60	357.49	-83.40	402.17	0.57	.57

Table 3 presents the additive values. In table 2 the absolute values tell how much difference there was in the event that over-estimation and under-estimation were mixed, and table 3 tells about what was over and what was under, specifically. The over-all assessment is that the scores did indeed tend to be mixed, for all participants, as shown by how much lower the mean scores are.

The standard deviations in table 3 are all considerably higher than the scores. They are also considerably higher than in table 2. This is because the possible range of answers is higher, with absolute scores, all numbers were by definition positive. Allowing numbers to remain negative essentially doubled the possible range, and the standard deviation, which measures how variable numbers are within a range, increases accordingly. These high differences in the means did not come out as statistically significant, just as before.

The skew and the kurtosis were verified to check if this distribution was normal. If the curve would lean too far over to the left or the right, then the skew would be above 1.0, and in all cases, it was lower. If the curve would be too peaked or too flat, then the kurtosis would be too high, and it never was. So the assumption of normality underlying the statistic was met for the case of the present study.

The correlation between the constant error and absolute constant error, that is, between the difference of the estimate from the real time which retains directionality and that which only measures the distance of the difference without reference to its directionality (positive or negative) is: r = -.04376, p = .812. This indicates these two measures are not correlated.

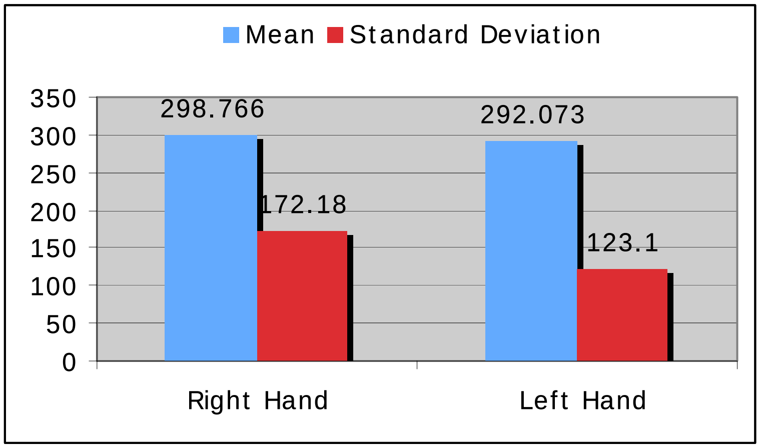


Figure 1. Total Additive Scores

Figure 1 shows the main test of the main research question. An interesting comparison is found, even though there are no significant differences in the means of the right-handers' and left-handers' performance in estimating short intervals of time (298.766 and 292.073), there is a noticeable difference in the standard deviation of right-handers (172.18) versus the standard deviation of left-handers (123.10).

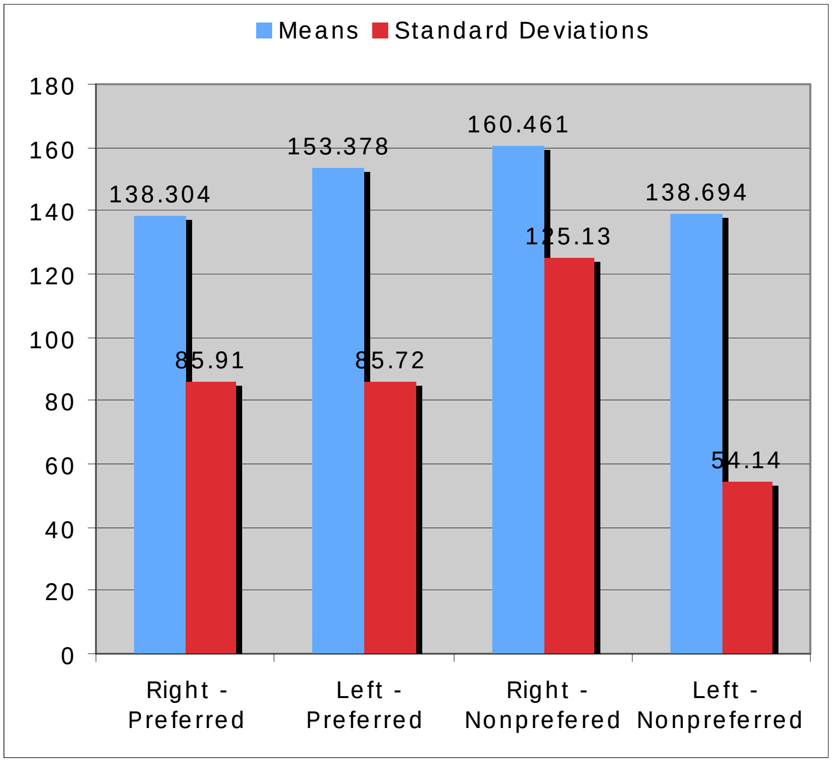


Figure 2. Hand Preference and Hand Usage

Figure 2 represents the means and standard deviations of the hand preference scores for both the right-handed and left-handed participants. As shown in this figure, there are no significant differences in performance between the two groups in hand preference, but there are noticeable differences in the standard deviations of participants when using their nonpreferred hands. When using their nonpreferred hand the standard deviation of the right-handers scores at 125.13, while for left-handers the score is 54.14.

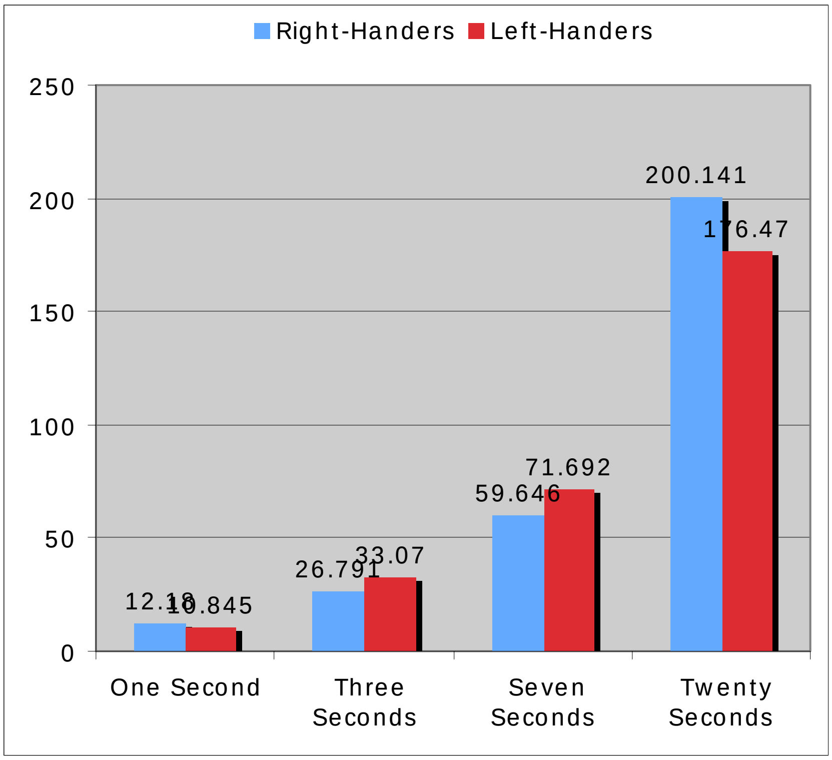


Figure 3. Means of Time By Hand

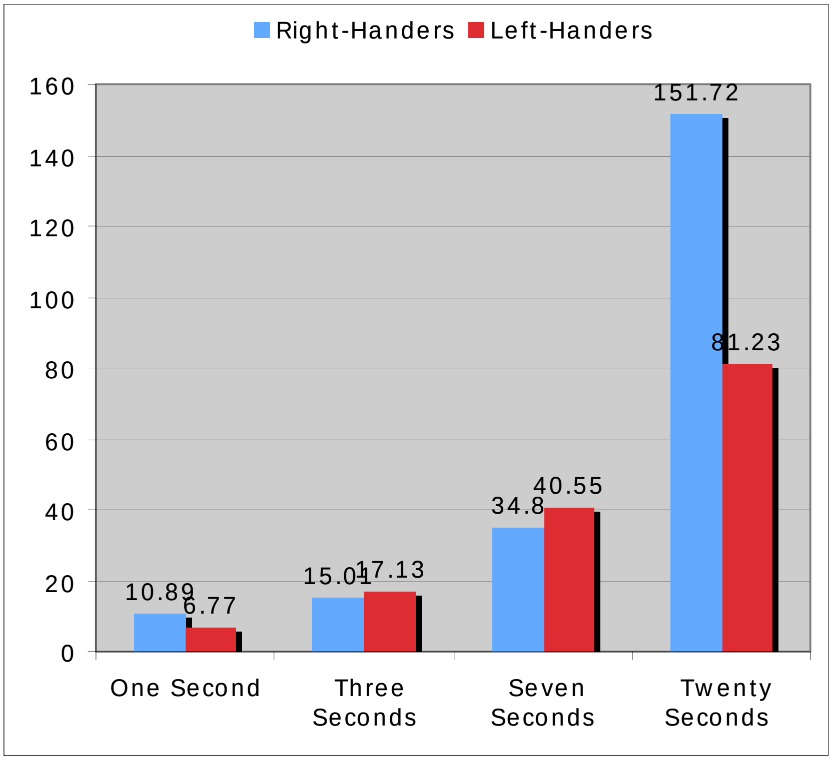


Figure 4. Standard Deviations of Time By Hand

Figure 3 presents the means of each one of the time intervals separated by the handedness of the participants. There are no significant differences between right- and left-handers for each of the separate time intervals. Figure 4 shows the standard deviations for those means. There is an interesting result when looking at the scores for the 20-second interval, where the standard deviation for the right-handed participants is 151.72, and 81.23 for the left-handed participants.

Table 4

Hand Preference and Hand Usage: Means and Standard Deviation

	Right Handers				Left Handers			
	Right Hand		Left Hand		Right Hand		Left Hand	
	mean	sd	mean	sd	mean	sd	mean	sd
1 sec	1.146	.134	1.175	.148	1.144	.075	1.116	.085
3 sec	3.339	.189	3.330	.202	3.634	.426	3.400	.244
7 sec	7.722	.414	7.769	.480	7.956	.534	7.832	.497
20 sec	22.267	1.733	22.737	3.160	21.926	1.142	22.486	1.733

Table 5

Hand Preference and Hand Usage: Coefficient of Variance

	Right Handers		Left Handers	
	Right Hand	Left Hand	Right Hand	Left Hand
1 sec	11.69	12.59	6.55	7.61
3 sec	5.66	6.06	11.72	7.17
7 sec	5.36	6.17	6.71	6.34
20 sec	7.78	13.89	5.20	7.70

Table 6

Hand Preference and Hand Usage: Duration Judgment Ratio

	Right Handers		Left Handers	
	Right Hand	Left Hand	Right Hand	Left Hand
1 sec	1.146	1.175	1.144	1.116
3 sec	1.113	1.111	1.211	1.133
7 sec	1.103	1.109	1.136	1.118
20 sec	1.113	1.136	1.096	1.124

Table 4 presents the summary of raw score data. Means for hand preference by hand usage are shown with respective standard deviations. Table 5 presents the coefficient of variation for the values presented in table 4. The coefficient of variation expresses the standard deviation as a percentage of the mean, it is a statistical measure of the deviation of a variable from its mean. Table 6 presents the duration judgment ratio or the accuracy ratio. This is a measure of the time estimates expressed as a ratio of the requested time interval. The most notable result when comparing participants of different hand preference, is the consistency of increased variability when right-handers are asked to used their nonpreferred hand. This change in variability is not present when left-handers are asked to use their nonpreferred hand.

Table 7

Gender: Means and Standard Deviations

	Right Handers				Left Handers			
	Male		Female		Male		Female	
	mean	sd	mean	sd	mean	sd	mean	sd
1 sec	1.097	.496	1.059	.156	1.018	.330	1.027	.279
3 sec	2.498	.849	2.770	.460	2.674	.708	2.219	.693
7 sec	6.324	1.842	6.806	1.498	6.787	1.653	6.008	2.206
20 sec	20.504	10.008	21.436	4.021	19.384	4.750	19.867	8.242

Table 8

Gender: Coefficient of Variance

	Right Handers		Left Handers	
	Male	Female	Male	Female
1 sec	45.21	14.73	32.41	27.16
3 sec	33.98	16.60	26.47	31.23
7 sec	29.12	22.00	24.35	36.71
20 sec	48.80	18.75	24.50	41.48

Table 9

Gender: Duration Judgment Ratio

	Right Handers		Left Handers	
	Male	Female	Male	Female
1 sec	1.097	1.059	1.018	1.027
3 sec	0.832	0.923	0.891	0.739
7 sec	0.903	0.972	0.969	0.858
20 sec	1.025	1.071	0.969	0.993

Table 7 presents the summary of raw score data by gender. Means for females and males are shown with respective standard deviations. Table 8 presents the coefficient of variation for the values presented in table 7. The coefficient of variation expresses the standard deviation as a percentage of the mean, it is a statistical measure of the deviation of a variable from its mean. Table 9 presents the duration judgment ratio or the accuracy ratio. This is a measure of the time estimates expressed as a ratio of the requested time interval. Although there are no differences in the mean scores on the performance of males versus females, it is to be noted that the left-handed females show more variability than the right-handed females, while the right-handed males show more variability than the left-handed males. Indeed, with only one exception (left-handed females in the 7 second interval condition) the variability of the right-handed males is higher than the variability of all other groups.

In summary, the results show no significant differences in the mean scores of the performance of right-handed versus left-handed participants, nor for the male versus female participants. However, it is interesting to note the large differences in the variability of the scores of the right-handed participants when using their nonpreferred hand. The variability is not as large in the left-handed participants in the use of their nonpreferred hand.

Table 10

Analysis of variance

PREFER	F = .040	eta = .001
PREFER X SEX	F = .001	eta = .000
PREFER X HAND	F = .041	eta = .002
PREFER X SEX X HAND	F = 9.228	eta = .255

Additionally as an exploratory measure, including gender in an ANOVA seems to show some differences in performance. These differences were not found when looking at the individual factors as demonstrated in table 10, but a statistical difference was found in PREFER by SEX by HAND, at $F = 9.228$, $p = .005$ (see figure 5). When adding SEX with these variables there is a surprising interaction effect. It is not just gender itself, but gender in combination with other variables. This study presents evidence of gender differences, not by itself but in interaction with other variables. No initial hypothesis for this possibility was included in the present study. This is an exploratory statistic, which may serve to generate other hypotheses for future research.

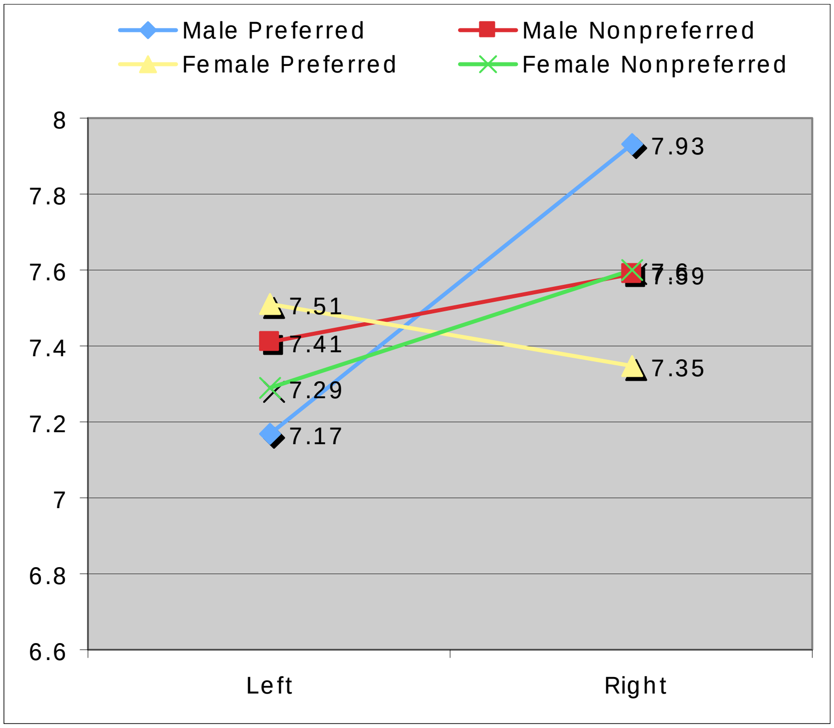


Figure 5 ANOVA Interaction: PREFER by SEX by HAND

DISCUSSION

The purpose of the present study was to evaluate the effects of handedness on the ability to estimate time by producing short duration intervals. The theoretical foundation of the work was based on the concept of an endogenous temporal mechanism, which may vary systematically in individuals of different hand dominance.

Humans require information about time for orientation in their world. Time is a systematic tendency, an organization of mental representations, the way by which people give order to their experiences (Michon & Jackson, 1985). Everyone is required to manage time and the perception of time is required for dealing with changes in the environment. It is understood that subjective or psychological time develops from two sources: from inner experience and from various changes and motions in the world. These two sources suggest that time provides a link between the mental and physical worlds (Denbigh, 1981). To explore one possible element of this link, the purpose of this study was to investigate the relationship of hand preference (an element of inner experience) to the estimation of time intervals (an element of change in the world).

Coren (1992) explains that manual performance has been used to assess asymmetries of hemispheric function. The hemisphere contralateral to the side of the acting hand primarily controls unilateral motor performance. Halpern (2000) reviewed the research literature, which documents the discovery that left-handers differ from right-handers on some cognitive abilities. The present study investigated time perception as a specific cognitive ability in which right-handers and left-handers might differ.

The temporal analysis of information is one of the basic mechanisms of cerebral function. The central nervous system continuously receives information that needs to be analyzed temporally for an adequate perception of the environment (Artieda & Pastor, 1996). Differences in brain lateralization have been shown to be present between left- and right-handers (Ornstein, 1977). If handedness is a factor in the timing process, this could reflect differences between the hemispheres of the brain. It follows then that if one hemisphere were more competent regarding time perception, the contralateral hand would be more accurate in judging duration.

Thirty-two adults participated as volunteers in this study. Participants were students at the University of Central Florida, who ranged from 18 to 24 years of age. Each of two groups, 16 males and 16 females, were comprised of equal numbers of right-handers (8) and left-handers (8). Participants were asked to estimate the requested time periods using the time estimation method known as the production procedure for empty intervals (Bindra & Waksberg, 1956; Clausen, 1950: Guay & Salmoni, 1988: Doob, 1971).

Research Questions and Hypotheses

Maccoby and Jacklin (1974) assert that there are differences in cognitive performance between the sexes. A major theory of sex differences in brain organization concerns the possibility that female and male brains differ in how the two hemispheres are specialised for different tasks. Given that the types of abilities that differ by hemisphere of specialization are the same ones that differ by sex, it seems probable that the sexes differ in the way their hemispheres specialize these abilities (Halpern, 2000). Given that there seems to be evidence for sex differences in cerebral lateralization, researchers have considered the possibility that sex differences in cognitive abilities may in fact reflect sex differences in the underlying neural structure or organization of the brain (Halpern, 2000).

Block, Hancock, and Zakay (2000) additionally reported differences between men and women in temporal cognition. Research in the field of time perception provides evidence that women make relatively larger and more variable estimates of duration than men do. Women either underestimate durations more often than men do or tend to estimate a subjective duration that is longer than the objective duration, while men do not significantly do so. Study design and other influences may affect the presence or absence of sex differences but in general, the literature acknowledges that there are sex differences in both the magnitude and variability of duration judgments (Block, Hancock, & Zakay, 2000).

Handedness is important not only as a major neuropsychological phenomenon but also as a secondary variable for interpreting other processes (McManus & Bryden, 1992). Handedness demonstrates contralateral control, that is, the point of origin is the hemisphere opposite the dominant hand. Organic qualities of the hemisphere affords the dominant hand a greater measure of competence, precision, expression, or force than is afforded the other hand by its controlling hemisphere (Harris, 1992). Contralateral control in left-handers may help understand the relationship of laterality to cognitive, perceptual, and emotional development.

This study anticipated that insights could be gained concerning the following aspects of this relationship between laterality and time perception: the consistency of time judgments and the effect of the relationship between hand preference and the length of the interval on this consistency; the influence of hand preference on the estimates of time intervals in terms of the average error (accuracy) and the constant error (over and underestimation of the intervals); the difference between right- and left-handers concerning time judgments; the relationship between handedness and accuracy, or a tendency to over or underestimate time; the relationship between hand preference and the length of the interval; and, the variability between right- and left-handers as far as time estimations are concerned.

If handedness contributes significantly to the timing process, this may indicate differences between the hemispheres of the brain as a potential explanation. If there is cerebral asymmetry in time perception, namely if one hemisphere is more competent regarding time perception, accuracy in judging duration should be higher for the contralateral hand. Therefore the following results were expected: Right-handed subjects will estimate time significantly more accurately than left handed subjects; males will estimate time significantly more accurately than females; and subjects using their preferred hand will estimate time significantly more accurately than subjects using their nonpreferred hand.

The research questions explored by this work were: First, how consistent are the participants in their time judgments? Do hand preference and the length of the interval, as revealed by the reliability of time judgments, in any way affect this consistency? Second, does the subject's hand preference significantly influence the estimates of time intervals in terms of the average error (accuracy) and the constant error (over and underestimation of the intervals)? Third, is there any significant difference between right- and left-handers concerning time judgments? Does there exist a relationship between handedness and a more accurate feeling of time or a constant tendency to over or underestimate time? Fourth, does the effect of hand preference on time estimation depend on the length of the interval? Fifth, how do right and left-handers differ in variability as far as time estimations are concerned?

Analysis of the Research Design and Implementation

There are reported sex differences in temporal cognition, and the nature of the differences has been shown to depend on how they are measured. When the task involves a verbal response, females give longer estimates than do males, but when the response requires producing a time interval, females produce intervals that are shorter than those produced by males (Hancock, Arthur, Chrysler, & Lee, 1994; Zakay & Block, 1997). Block, Hancock, and Zakay (2000) concluded that there are small but reliable differences in the way females and males judge the passage of time. These differences are moderated by many variables, including the way in which time judgments are assessed.

The intervals used in the experimentation on time estimation range anywhere from short to long, from milliseconds to several minutes. Dobson (1954) states that the length of the interval can possibly exert a significant influence on the estimation of time both in terms of accuracy and constant error, due to the fact that the estimation of different lengths might be mediated by different mechanisms of time evaluation. How exactly the length of the time interval affects time estimation is still an unanswered question. Although some evidence exists that there is a tendency for less accuracy with increasing time intervals (Dobson, 1954). One possible explanation for this is provided by Guay and Salmoni (1988). They refer to the "lengthening effect" in which the participants' time estimates get longer over blocks of trials. Warm, Morris, and Kew (1963) interpreted this effect as the result of increased boredom during the performance of a repetitive task. Treisman (1963) on the other hand, explained this effect as being due to changes in specific temporal arousal, so that it is related to the internal time keeping mechanism.

Handedness is important in that it serves as a potential neuropsychological marker of underlying brain development and may also reflect the manner in which cognitive functions are localized to the left or right cerebral hemispheres (O'Boyle & Benbow, 1990). This proposed link between brain function and hand dominance provides reason to research the fact that hand preference may systematically relate to individual differences in cognitive tasks. One of these tasks may be time estimation and investigating this potential link was the main purpose of this study.

Significance and Use of the Findings

If some evidence could be obtained in favor of the hypothesis that hand preference in some way affects time estimation, this would be a useful contribution to the field of psychology and the understanding of the processes involved in time estimation. This would contribute to the further understanding of factors and variables involved in time estimation, and thus help comprehend better this area of psychological inquiry. This could shed some light on the general question of hand preference with reference to the ability to estimate time.

People do show considerable differences in their efficiency with time. Some of these differences may possibly result from differences in a basic ability to perceive and estimate time intervals (Wickens, 1992). The practical implications of research and theory on time perception are as numerous as the cases in which a human operator is expected to keep track of time while performing a task. Marmaras, Vassilakis, and Dounias (1995) propose that a specific area, where the ability to estimate time may be significant, is in the performance of work tasks. One key component in the designation of work is designing schedules and procedures in terms of time intervals during which the worker must perform predetermined actions. These can be anywhere from a period of seconds to several hours. In these situations, concurrent tasks may be required and in most situations, a time signal or device may be unavailable or ignored. Under these circumstances, the accuracy of time estimation by the human operator is critical for the performance of the work system and is also an important component for human reliability and system safety (Decortis & Cacciabue, 1988).

Porac and Coren (1981) refer to The Right-Sided World Hypothesis, which observes that most tools, equipment, furniture, traffic patterns, and seating arrangements are designed for right-handers. This forces left-handers to live in a world of right-handed objects and customs.

Halpern and Coren (1990) propose that this right-handed design of the world may go beyond just inconvenience, and actually constitute a danger for left-handers. A possible explanation given by Halpern and Coren (1991) may be that left-handers are placing themselves at some risk when they are forced to use their nonpreferred hand when working with equipment and in environments designed for right-handers.

Although the design of environments may facilitate the use and comfort of right-handed users, it may very well have direct negative implications for the comfort, efficiency, and survival of left-handers. The typical patterns of left-handed behavior do not fit in with the requirements of the right-sided world, and this places them at a higher risk of accidents.

Because left-handers are reported to differ from right-handers in certain cognitive abilities and tasks and to be more frequent in certain clinical and special populations, the understanding of left-handedness may be the key to understanding the relationship of laterality to cognitive, perceptual, and emotional development (Harris, 1992).

The results of studies of handedness and time perception can be used to show the importance of using hand preference in the assignment of work tasks. If handedness is crucial in estimating time, this could be tested first. Employers could confirm if employees are right-handed or left-handed and this could be a factor in who to assign to a job where estimating time is a crucial part of the task. The possible application to follow is to improve performance and safety by either not placing left-handers in those positions, or taking handedness into consideration when designing or redesigning a task.

Results and Discussion

The results are presented as additive scores of the absolute values of the differences between the time interval to be estimated, and the actual estimate given. In all cases, the score was found by subtracting the actual time from the time estimate, taking the absolute value of that, and then adding them all together (not averaging them).

Although no significance was found in the means regarding actual performance in estimating short intervals of time, the standard deviation was found to be quite different as an indication of higher variability under certain circumstances. The standard deviations seem to be fairly different from each other in the following dependent measures: nonpreferred hand, 1 second, 20 seconds, right-hand usage, and left-hand usage. In each case the standard deviation among the right-handed participants was found to be much higher than for the left-handed participants.

When examining the main test of the main research question, an interesting comparison is found. Even though there are no significant differences in the means of the right-handers' and left-handers' performance in estimating short intervals of time (298.766 and 292.073), there is a prominent difference in the standard deviation of right-handers (172.18) versus the standard deviation of left-handers (123.10).

When examining the means of the hand preference and hand usage for both the right-handed and left-handed participants, there are no significant differences in performance between the two groups in either hand preference or hand usage. On the other hand, when examining the standard deviations for those means, there are noticeable differences in the scores of participants when using their nonpreferred hands. When using their nonpreferred hand the standard deviation of the right-handers is 125.13, while for left-handers the score is 54.14. For hand usage, the standard deviation of the right-handers is 125.13 and the left-handers is 85.72.

When examining the means of each one of the time intervals separated by the handedness of the participants, there are no significant differences between right- and left-handers for each of the separate time intervals. When examining the standard deviations for those means, there is an interesting result in the scores for the 20-second interval, where the standard deviation for the right-handed participants is 151.72, and 81.23 for the left-handed participants.

In general, the results show no significant difference in the mean scores of the performance of right-handed versus left-handed participants, nor for the male versus female participants. However, it is interesting to note the large differences in the variability of the scores of the right-handed participants when using their nonpreferred hand. The variability is not as large in the left-handed participants in the use of their nonpreferred hand. One possible explanation for this finding is what Porac and Coren (1981) refer to as The Right-Sided World Hypothesis. Left-handers are accustomed to living in a world designed by and for right-handers, and therefore are forced much more often to use their right-hand, their nonpreferred hand. This continual practice in their daily lives may be the reason why their standard deviations are lower in the present study. Conversely, right-handers are hardly ever expected to use their left, or nonpreferred hand. Hence, when asked to do so in this study, some right-handed participants showed greater variability in their standard deviation scores, possibly reflecting the fact that they have very little, if any, practice using their left hands in their daily lives.

Summary and Conclusions

No sense or sense organ by which time can be perceived directly is known, nor is it clear what information humans utilize to make time estimates (Zakay, 1990). Sensing the passage of time is not a single, independent function but arises from multiple feedbacks as the organism responds to both the internal and external environments. The way humans organize and interpret these experiences shapes their perspective of time.

There is a continuing interest in the relationship among handedness, sex, and cognitive processes. Three patterns of results have contributed to this interest (Carter-Saltzman, 1979): (1) The disproportionately high incidence of males and left-handers or mixed handers in clinical groups of children with reading and learning disabilities, social cognitive disorders such as autism, and speech problems such as stuttering. (2) The finding that males and females may have different patterns of hemispheric specialization for cognitive functions and that these patterns may be related to handedness. (3) The frequently reported existence of sex related differences in adulthood on tests of spatial visualization (males perform better than females), visual memory tests (females perform better than males), and handedness (more left-handed males and/or more ambidextrous males than females). The research question for the present study refers to the comparison of left-handed and right-handed participants.

The combined results of numerous studies indicate that males and females do perform differently on certain types of cognitive tasks (Halpern, 2000; Block, Hancock, & Zakay, 2000; Hancock, Vercruyssen, & Rodenburg, 1992). One possible explanation for this finding is that there is a sex-related difference in the organization of higher cortical functions, expressed behaviorally as a sex-related difference in cognitive abilities. Evidence from studies of laterality in normal participants indicates that there may actually be a sex-related difference in cerebral organization; thus, certain sex-related differences may be due to fundamental differences in neurologic organization (Halpern, 2000).

In comparison to the present study in which no gender differences where found, the study by Hancock, Arthur, Chrysler, and Lee (1994) found that illumination reduced the variability of responses in women but not in men. In comparison, the present study shows means that are closer to accurate than the illumination study. The sample in the present study was closer to accurate, but this sample had much higher standard deviations than the sample in the illumination study. The participants in the illumination study tens to be less variable, when at the same time the scores themselves are less close to accurate. This may possibly suggest that the present study has more participants who are indeed off in their estimates, but off in different directions so that they cancel each other out when averaged. In the present study, it is to be noted that the right-handed males have higher standard deviations across all measures compared to the left-handed males. While it was the left-handed females who had higher standard deviations than the right-handed females. This could perhaps indicate something of a gender difference related to handedness, which would suggest the need for further study.

The purpose of this study was to compare gender and handedness to the ability to estimate time intervals. With that goal, the primary purpose of this study was to determine empirically whether females and males of different handedness have different views of time. Experimental psychology is concerned with the study of subjective time but in spite of many efforts, the results are not very encouraging because many conclusions are contradictory, several areas of the problem have remained unexplored, and a complete and conclusive psychology of time estimation has not been achieved. The secondary purpose of this study was to extend the methods as reported in the literature to a sample of a normal, functioning population in an effort to evaluate how different handedness groups view and estimate time and to determine if the ability to estimate time is affected by hand preference.

Although the brain appears symmetric, extensive research has indeed shown that each side of the brain controls different functions. The left half of the cortex receives sensory information about the right half of the world, and it controls the motor responses on the right side of the body. Sensory information and motor control for the left half of the world are under the control of the right hemisphere (Halpern, 2000). Thus, brain mechanisms for sensory input and motor output are under contralateral (opposite side) control. Because the right hemisphere controls the movements of the left side of the body and the left hemisphere controls the movements of the right side of the body, most right-handers have dominant motor control in their left hemisphere, and most left-handers have dominant motor control in their right hemisphere. Hand differences are of particular interest in the study of brain organization because preferred hand use is an indirect index of lateralization of brain dominance (Halpern, 2000).

The differences that are found between right- and left-handers in cognitive abilities are known to be lateralized. Halpern and Coren (1990) state these differences would create at least two possibilities for left-handers: overall poor performance by left-handers on cognitive tasks that are associated with the left hemisphere, and/or exceptionally high performance on cognitive tasks that are believed to be primarily under right hemisphere control.

A goal of handedness research has been to determine whether having a left hand attached to a hemisphere with different functional skills than the hemisphere attached to the right hand translates into differences in the behavior of left- and right-handers. In left-handed people brain organization is often different from that of right-handed people. There are well documented differences between right- and left-handers in the lateral organization of higher cognitive functions in the cerebral cortex (Harris, 1992). The present study attempted to examine if this causes a difference in one additional specific cognitive function: the comparison of the ability of right- and left-handers to perceive short intervals of time.

According to the results found in the present study, the actual practical application proposed before appears not to be needed in the design of work tasks. When assigning tasks to human operators, their hand preference may not need to be taken into account at least as short time estimations are concerned, if the estimation of these is essential to the task to be assigned. Actually knowing that handedness does not play a role in the estimation of short intervals, would be helpful knowledge, so that other factors may be given more time and consideration when designing or assigning work tasks. Of course, additional research would be needed to confirm this conclusion.

Hardyck, Petrinovich, and Goldman (1976) examined and compared the results of 33 studies of intellectual and performance measures of right- and left-handers. The studies covered the areas where some deficit is postulated to exist in left-handers, such as: reading ability, intelligence, retardation, perceptual performance, alcoholism, emotional instability, and stressful conditions at the time of birth. When examining the relationship between possible deficits associated with left-handedness, the authors suggest that the results strongly support that there are no differences in intellectual and cognitive performance between right- and left-handers.

The lack of significance in the results of the present study possibly suggest that time perception may be one more cognitive and performance measure where real differences are not found between right- and left-handers. This could be used as further evidence to the fact that there is no need to discriminate between individuals of different handedness.

Limitations of the Present Study

The proposed link between brain laterality and individual differences in cognitive tasks (O’Boyle & Benbow, 1990) provided the theoretical foundation for the present study. The main purpose of this study was to investigate this potential link, specifically between one aspect of brain function, namely hand dominance, and one type of cognitive task, namely the ability to perceive short intervals of time.

Within this purpose, the present study did include some foreseeable limitations and restrictions. One possible limitation of this study was the possibility that participants, after removing their watches or other forms of timekeepers, may still use some form of time estimation strategies even when instructed not to, such as counting in their heads. The shortness of the time intervals may be an additional limitation regardless of any estimation strategies used by the participants.

The major limitation of this study is the small sample sized included and on which the results are based. The sample size was a direct result of the difficulty in locating true and total left-handers in the college population who were also willing, able and available to participate in the time estimation experiment. Hardyck, Petrinovich, and Goldman (1976) explain that as a result of the low incidence of left-handers in the general population, even large samples result in small numbers of left-handed participants. For example, Wilson and Dolan (1931) conducted a study which included 931 right-handed students but only 44 left-handed students. In another example, in a sample of 409 men and 414 women, a study by Newcombe and Ratcliff (1973) found only 15 left-handed males and 11 left-handed females. In a further example, a study by Ashton and McFarland (1991) included 981 right-handed participants but only 55 left-handed participants.

For the present study, in a period of over a year, 1,276 volunteers took the Edinburgh Handedness Inventory online as a screening device to qualify for the time estimation part of the study, based on their scores on the inventory. The small sample used in this study is in part due to the criteria for participation in classifying handedness by only including the extreme scores on the Edinburgh Handedness Inventory. Of the 1,276 volunteers only a small percentage scored as strongly left-handed with scores between -18 and -20, as required by the present study. Attempts were made to contact all of them and those who were interested and available at the time were invited to participate in the time estimation task. Eventually only eight males and eight females were available to participate and this consequently, determined the number of right-handed participants, resulting in a total sample of N = 32.

For the present study the value of Cohen's d, a measure of how large the difference is, had an effect size of .2. This is small to moderate, and it points to the need for a larger sample size in future research. The lack of significance may mean that the results will not be replicated, however, if there is enough of a size difference, this suggests that means are not so close as to make the pursuit useless.

Future Research

According to the literature, there is a sizeable difference in brain organization between right- and left-handers (Ornstein, 1977). The differences in the sides indicate that people have different kinds of hemispheric organization. About 90% of right-handers are typical in their cerebral organization, while only 66% of left-handers are (Ornstein, 1977), thus not everyone has the standard differences in the two sides of the brain. There are differences in brain organization between right- and left-handers and within right- and left-handers. As a matter of degree, some people are highly divided and others are more integrated. Further research could include brain imagery to determine the actual brain organization of participants by hand preference before comparing their ability to estimate time, eliminating the possibility that those differences may actually confound the results.

With the knowledge provided by the results of the present study which demonstrated no significant differences in the performance of right-handers and left-handers in their ability to estimate short intervals of time, it would follow that additional research could examine the ability to estimate longer intervals of time. It is possible that the estimation of longer intervals of time (minutes or an hour or longer, for example) may show unique differences not reflected by short intervals.

Another alternative study that may further help understand the differences in timing ability related to handedness, would be to conduct studies of filled intervals of time, those where the processing of nontemporal information is required, when the subject must process the information presented or perform some concurrent activity during the interval. Including this additional cognitive load might reveal differences between right-handers and left-handers not readily reflected when studying empty intervals of time.

The present study purposely included only participants representing both extremes in their handedness scores, those individuals who scored as either strongly right-handed (+18 to +20) or strongly left-handed (-18 to –20) in the Edinburgh Handedness Inventory. To study a different aspect, participants with less extreme scores should be included in future research to determine the ability to estimate time in people whose scores are closer to the center. It is possible that participants with extreme scores are actually more like one another than participants with scores closer to the middle. Additionally, it would be interesting to include truly ambidextrous participants, those with a score of zero in the Edinburgh Handedness Inventory.

The most intriguing result from this study, the greater variability of scores shown by right-handers than left-handers when using their nonpreferred hand, presents a host of possibilities for future research which might help illustrate the cause of this difference.

Given that right-handers in the present study seem to have more variation in their time estimates when using their nonpreferred hand, but that this is not consistent enough to show a difference in their overall means, different characteristics within right-handers could be examined that could perhaps influence their ability to use their nonpreferred hand. Alternatively, in view of the fact that left-handers seem to be more consistent in the estimation of short time intervals when they are asked to use their nonpreferred hand, this greater ability could be further examined to determine the possible explanation for this result. This difference in ability may be a product of the attitude of the subject (attention, motivation, expectations, stress), physiological factors (pulse, heart rate, breathing rate, temperature), or the subject's background (culture, age, gender), among others.

In studying the relationship between handedness and the ability to perceive time it may be of interest to contrast different groups of people in future research. Comparing people who belong to different groups such as culture, age, or gender, may provide insight into this relationship. For example, the ability to perceive time might vary with culture or ethnicity, depending on how permissive or restrictive the attitude is towards left-handedness in the culture studied. Similarly, comparing the ability to perceive time in different age groups may provide information about additional characteristics of the ability to perceive time. The participants in the present study were all college aged young adults. Nonetheless, it could be expected that an absence of differences found in this young sample may not yield the same results if the sample included in the study were older adults or children. In fact, the resiliency of relative youth and the experience of relative age when compared could make a difference in the results when examining their ability to estimate time influenced by hand preference.

As previously reported in the literature, gender differences may be found in brain laterality (Halpern, 2000), hand preference (Coren, 1992), and time perception (Block, Hancock, & Zakay, 2000). However, this relationship is not fully understood at this point so further research is necessary. In the present study, including gender in an ANOVA as an exploratory measure, seems to show some differences in performance. A statistical difference was found in PREFER by SEX by HAND, at $F = 9.228$, $p = .005$. When adding SEX with these two other variables there is a surprising interaction effect. It is not just gender itself, but gender in combination with these other variables. This presents evidence of some gender differences, not by itself but in interaction with other variables, such as hand preference and hand usage. No initial hypothesis for this was included in the present study but is included here as an exploratory statistic, which may serve to generate further hypotheses for future research.

Proposed model of time perception

In combining the biological and cognitive explanations of time perception, Hogan (1978) proposes that filled time will be judged as longer than empty time, on the principle that the more actively involved our perceptual and cognitive senses are during an event, the more stimulated our neurons will be; hence the more stimulated our neurons, the more neurological impressions we will have available to recall the event afterwards; so then it follows that the more impressions we have available for recall, the greater our memory of past experience; and the greater our memory of past experience, results in a greater amount of subjective time which will be associated with that given event.

Given this relationship between biology and cognition, along with the understood fact that the left hemisphere is capable of making finer temporal discriminations than the right hemisphere (Brown & Nicholls, 1997; Carmon & Nachson, 1971; Efron, 1963; Vroon, 1975) and sensory and motor control is under contralateral control in the brain, and the knowledge that on most cognitive measures, within-sex variability is greater for males than females (Feingold, 1992; Hedges & Nowell, 1995), the following model is hereby proposed for future comparisons and investigation.

A speculative model is proposed to compare two extreme groups in their ability to perceive the passage of time: left-handed females and right-handed males. Given that right-handed males are more lateralized in their brain structure, it is possible they may perceive the passage of time as slower with less activity than compared to left-handed females under a considerably higher level of activity, who will perceive time as moving much faster given their less lateralized hemispheres.

Consequently, the connection between time perception and sex and hand preference, continues to be an area where further knowledge and understanding is needed, and many conclusions are still left to be reached by future research.

APPENDIX A

EDINBURGH HANDEDNESS INVENTORY

Edinburgh Handedness Inventory

Instructions

For each of the ten activities below, please circle:

1. Which hand do you prefer for that activity?

2. Do you *ever* use the other hand for the activity?

Which hand do you prefer when:			Do you ever use the other hand?	
Writing:	Left	Right	Yes	No
Drawing:	Left	Right	Yes	No
Throwing:	Left	Right	Yes	No
Using Scissors:	Left	Right	Yes	No
Using a Toothbrush:	Left	Right	Yes	No
Using a Knife (without fork):	Left	Right	Yes	No
Using a Spoon:	Left	Right	Yes	No
Using a Broom (upper hand):	Left	Right	Yes	No
Striking a Match:	Left	Right	Yes	No
Opening a Box (lid):	Left	Right	Yes	No

APPENDIX B

CONSENT FORM

CONSENT FORM

You are invited to participate in a research study investigating the perception of time. You were selected as a possible participant because of the score you obtained on the online handedness questionnaire and you have normal or corrected to normal vision, are between the ages of 18 and 24, and possess no other apparent limitations.

This study is being conducted by Mar Rodriguez, ABD, a graduate student at the University of Central Florida, under the supervision of Peter Hancock, Ph.D., a faculty member of the Human Factors Psychology program at the University of Central Florida.

BACKGROUND INFORMATION: The purpose of this study is to examine the differences in time perception by gender and handedness.

PROCEDURES: If you agree to be in this study, we would ask that you do the following: Estimate time intervals of one, three, seven, and twenty seconds. Each time interval will be estimated forty times. An individual trial will be initiated by you by pressing a key and ended by pressing another key on a response box.

REQUIREMENTS: This study will require about one hour of your time to complete. There are no known risks associated with this study. A possible benefit you may derive from this study is to learn about a new research topic, if you didn't know about it from before.

CONFIDENTIALITY: The data in this study will become part of Mar Rodriguez's dissertation as a graduation requirement. The records of this study will be kept private. If any sort of report might be published, we will not include any information that will make it possible to identify a subject. The research records will be identified by a random number that will be impossible to pair with a participant's name, and only the researchers will have access to the records.

VOLUNTARY NATURE OF THE STUDY: Your decision, whether you choose to participate or not, will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting those relationships.

CONTACTS AND QUESTIONS: Please feel free to ask any questions you may have now or at any time during the procedure. If you have any questions later, you may contact the researchers at the Psychology Department 407-823-2216 or email merodrig@mail.ucf.edu or phancock@pegasus.cc.ucf.edu.

COMPENSATION: Participation in the study is voluntary. Compensation will be provided in one of two forms: the amount of $7.50 per hour <u>OR</u> extra credit by professors at their discretion.

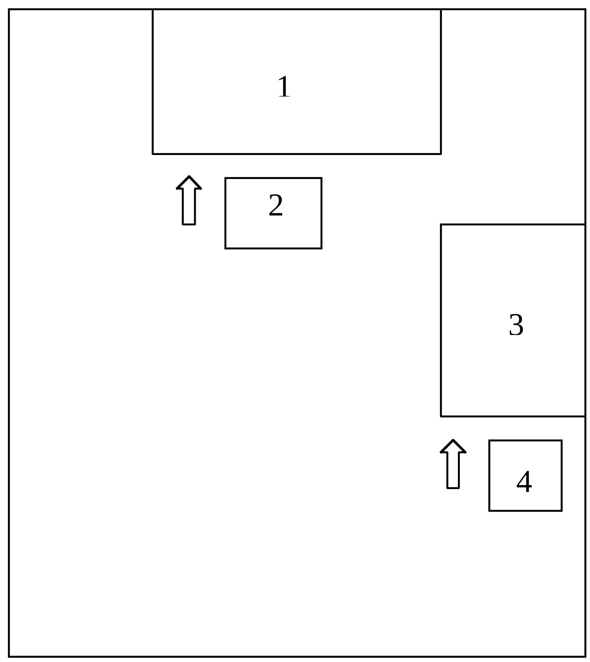
STATEMENT OF CONSENT: I, the participant, have read the above information and instructions. I have asked questions and have been provided answers. I consent to participate in this study.

Participant's Signature ____________________________________ Date _________________

APPENDIX C

EXPERIMENTAL SETTING

Experimental Setting



1. Table and two button timer

2. Participant

3. Experimenter Station

4. Experimenter

APPENDIX D

IRB APPROVAL

University of
Central
Florida

Office of Research

December 12, 2003

Maria Rodriguez
Department of Psychology
College of Arts and Sciences
University of Central Florida
4000 Central Florida Boulevard
Orlando, Florida 32816

Dear Ms. Rodriguez:

With reference to your protocol entitled, "Time Estimation and Hand Preference," I am enclosing for your records the approved, executed document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Chris Grayson
Institutional Review Board (IRB)

Copies: Peter Hancock
IRB File

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